

CHAPTER 4

OPERATING PRINCIPLES OF A REPRESENTATIVE UHF RADIO COMMUNICATIONS RECEIVER SET, AN/URR-35A

INTRODUCTION

The Radio Receiver Set, AN/URR-35A (fig. 4-1) is a complete receiver system which is designed to provide reception of voice amplitude-modulated (A-3) and MCW (A-2) signals in the frequency range from 225 to 400 megacycles. The theory of operation of the system receiver is discussed in this chapter. The AN/URR-35A receiving set replaces the RDZ receiving equipment which is now obsolete.

GENERAL DESCRIPTION OF MAJOR COMPONENTS

The Radio Receiver Set, AN/URR-35A (fig. 4-1) consists of: (1) a radio receiver, R-482A/URR-35; (2) a pair of brackets for mounting the receiver in a relay rack; (3) four plugs to mate with receptacles on the receiver for making external connections; (4) an electrical power cable assembly (CX-1869/U) and of cable assembly (CG-839/U); and (5) two copies of the equipment instruction book.

The system components are grouped, on a functional basis, into five major sections: (1) the preselector section (fig. 4-2A); (2) the IF/AF section; (3) the power supply section; (4) the front panel section (fig. 4-1); and (5) the low-pass filtering section (fig. 4-2B).

The first three major sections of the receiving set are located within the receiver frame (fig. 4-2A). The purpose of each of these sections is implied in the section name. The front panel section is connected to the front of the receiver frame (fig. 4-1). This section contains all controls and meters which are required for operation and monitoring of the receiver circuits.

The low-pass filter section of the receiving set is attached to the rear of the receiver cabinet (fig. 4-2B). This section contains r-f noise filter circuits for the power input and audio output circuits. It also provides jacks, from which

the appropriate cable assembly (as mentioned above) can be used to connect the antenna input to the receiver, and when desired, to connect the scan channel receiver output to a panoramic adapter. A scan channel terminating plug, E401, is also contained on the low-pass filter section, which should be used for properly terminating the scan channel circuits when the panoramic feature of the receiver is not being used.

The Radio Receiving Set, AN/URR-35A contains a dual conversion (double-superheterodyne) UHF receiver chassis (R-482/URR-35 of fig. 4-1) which is designed primarily for operation as a pretuned, single-channel crystal-controlled receiver. The crystal holder and various receiver controls are located behind small doors to the left and right of the receiver chassis (fig. 4-3). By employing a suitable crystal, any channel within the frequency range of the receiver may be selected.

Continuously variable manual tuning is also a feature of the receiver. A single tuning control (fig. 4-3) is employed for tuning to any frequency for either crystal-controlled or manual tuning operation. Either of these two methods of operation is selected by an oscillator switch on the receiver front panel.

The receiver produces a 10 db signal-to-noise ratio when an 8 microvolt r-f signal modulated 30% with a 1000 cps audio note is received from the antenna via a 50-ohm line.

BLOCK DIAGRAM

The block diagram (fig. 4-4) reveals that the receiver is of conventional design except for the dual conversion feature. However, because of the high frequencies at which the receiver operates (225 to 400 mc) many special circuits are employed which improve the overall efficiency of the receiver.

The received signal from the antenna is coupled via J404 to the first r-f amplifier, which comprises V101 and V102 in a push-pull circuit

CIRCUITRY OF SHIPBOARD ELECTRONICS EQUIPMENT

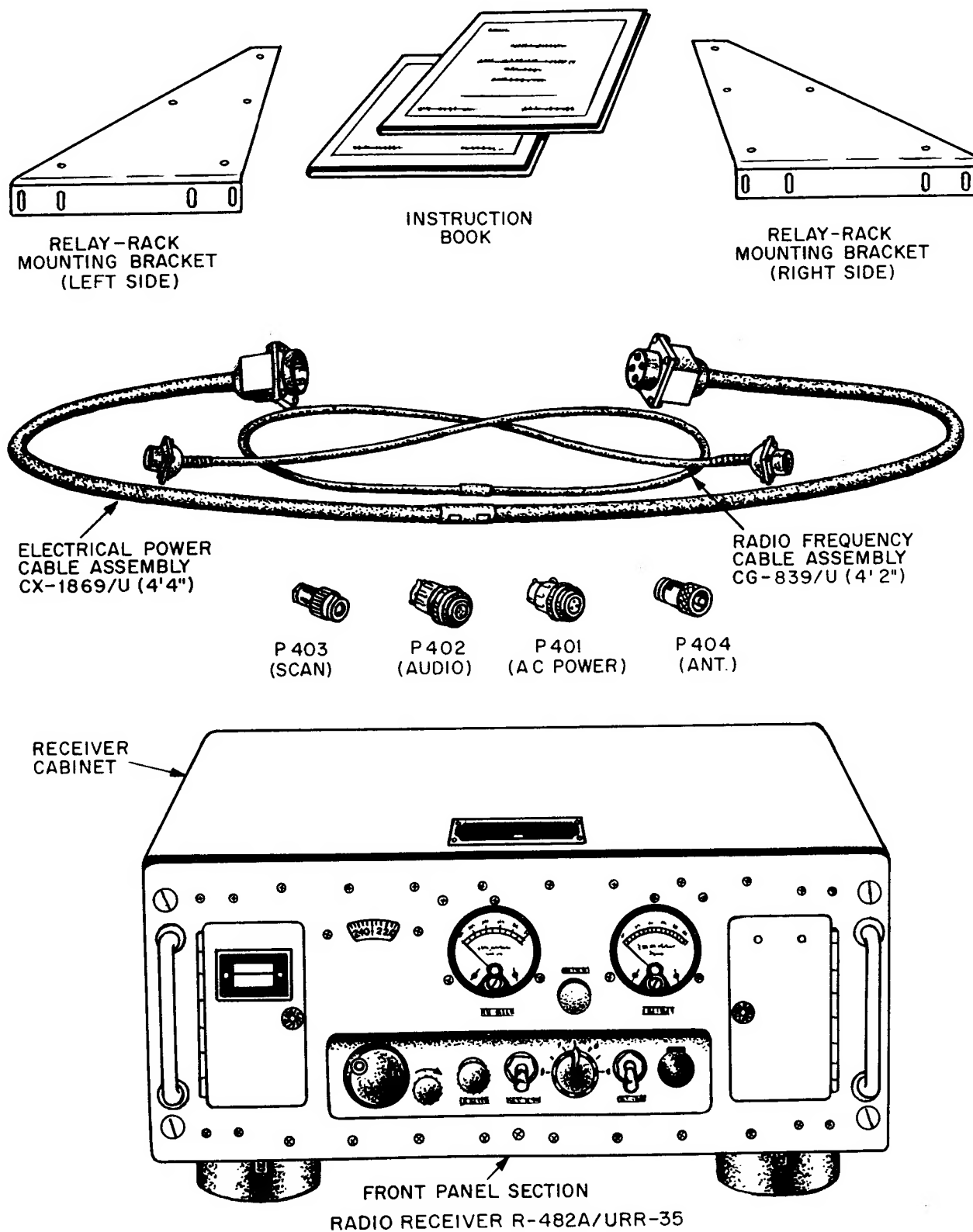
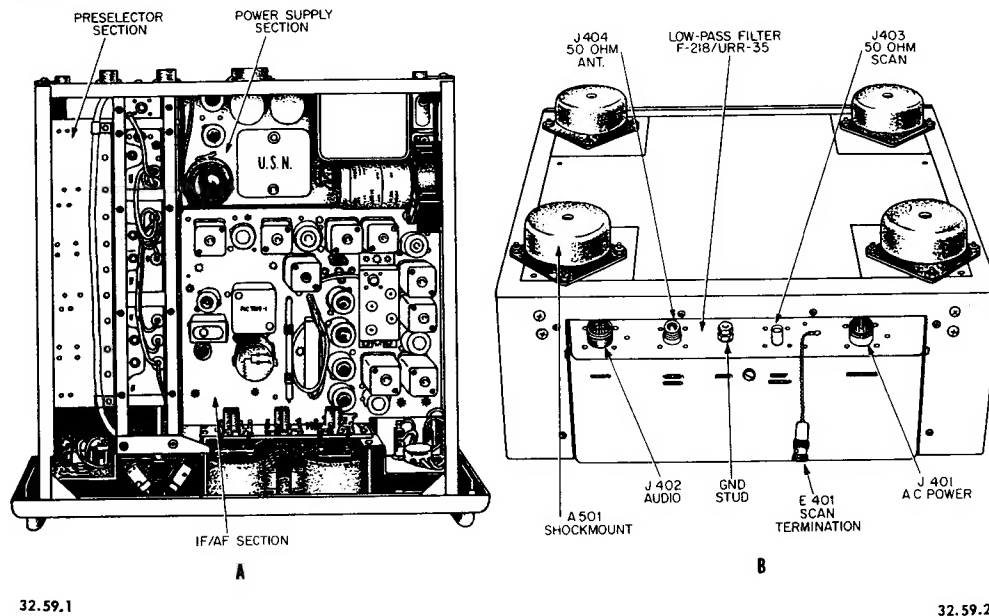


Figure 4-1.—Radio Receiving Set, AN/URR-35A.



A. Radio Receiving Chassis, R-482/URR-35.
 B. Radio receiving cabinet (rear-view upside-down) showing low pass filter sections and connections.

Figure 4-2.—Receiving set pictorial diagrams.

arrangement. The amplified output of V101 and V102 is applied to the second r-f amplifier (comprising V103 and V104 in push-pull) and thence to the first mixer, V105. The local oscillator signal is obtained from an oscillator stage, V106A, followed by three stages of frequency multiplication, (V106B through V109).

The tuning arrangement for the two push-pull connected r-f amplifiers (comprising V101 through V104) and the mixer stage, V105, is geared to that of the local oscillator and multiplier stages to provide single-control tuning. This control is shown as number 18 in figure 4-3.

The first local oscillator functions as either a crystal-controlled or self-excited circuit, depending upon the position of the OSC switch (number 20 of fig. 4-3).

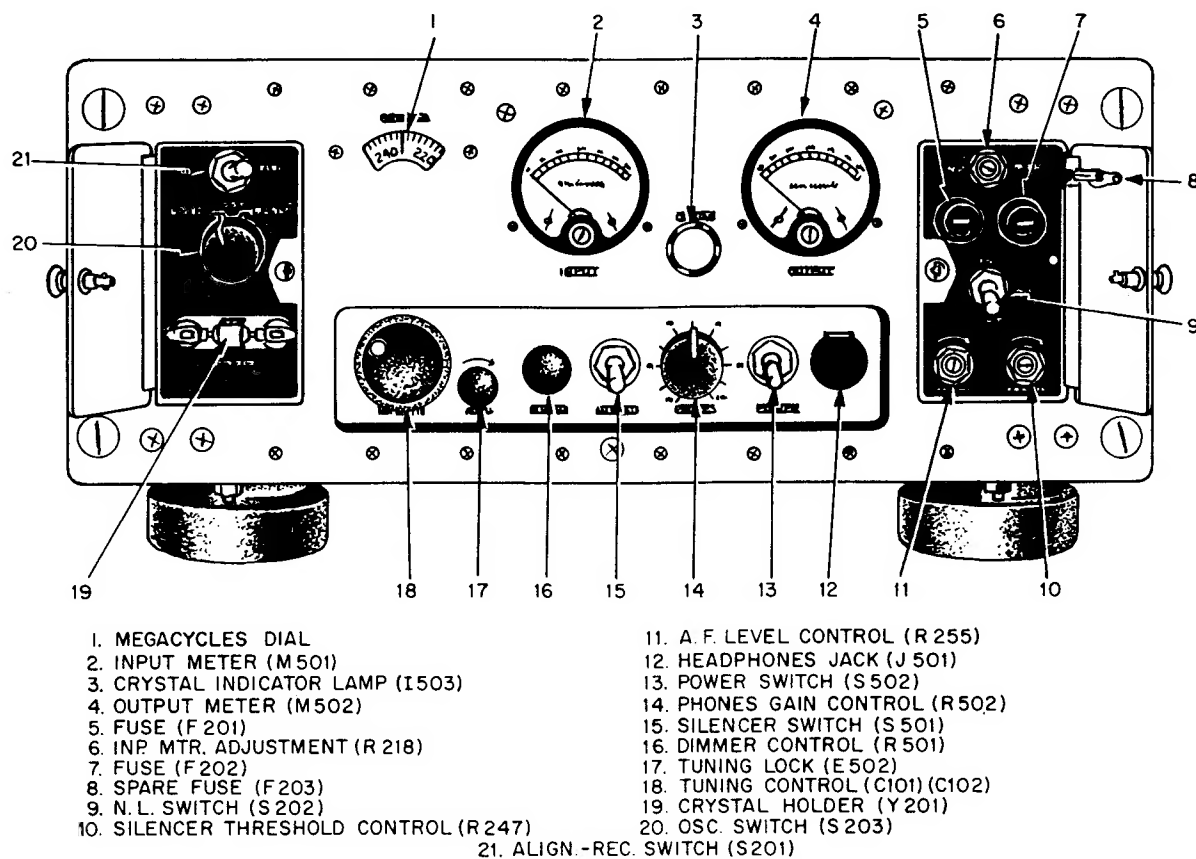
The first mixer, V105, output signal at a frequency of 18.6 megacycles, is fed to a first i-f amplifier, V201, and to a scan-channel amplifier, V202. The first i-f amplifier, V201, amplifies the 18.6 mc signal and applies its output to the second mixer stage, V203A.

A second local oscillator signal at 16.825 mc from V203B is applied to the mixer, V203A. The heterodyning process in V203A produces a 1.775 mc output from the second mixer.

The portion of the first mixer, V105, output signal which is applied to the scan-channel amplifier, V202, is amplified in this stage. The V202 output is applied to the 50-ohm scan jack, J403, on the low-pass filter (fig. 4-2B). The scan output is provided for use with a panoramic adapter when it is desired to view the received signal. The scanning channel has a bandwidth of 0.7 mc, passing frequencies from 300 to 1000 kilocycles at 6 db down on the response curve half-voltage points).

The stages comprising V204 and V205 (fig. 4-4) are conventional intermediate amplifiers. These stages amplify the 1.775 mc i-f signal from V203A. The i-f output from V205 is rectified and filtered in the detector stage, V206A.

The stage to which the detector (V206A) output is coupled is determined by the setting of the silencer and noise limiter switches, S501 and S202 respectively. With these switches in the position shown, the detector output is fed through a noise limiter, V206B, and a silencer diode, V208B. The conducting and nonconducting condition of V208B is determined by the combined action of the AGC silencer amplifier, V207, and the AGC silencer diode, V208A. When both of the switches (S501 and S202) are in the OUT position (opposite to the setting shown) the



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Figure 4-3.—Radio Receiver, R482/URR-35, operating controls.

detector (V206A) output is applied through the switch (OUT) contacts to the first audio amplifier, V209A.

The audio signal amplitude is increased in three stages of audio amplification comprising V209A, V209B, and V210. The audio output stage (V210) applies its signal to the headphone jack, J501, and to the output meter, M502. This signal is also applied through the low-pass filter (fig. 4-2B) to the audio output jack, J402.

All power necessary for operation of the equipment is obtained from a built-in power supply which can be adjusted to operate from a 105-, 115-, or 125-volt 50 to 60 cps single-phase input power source. The power transformer, T301, and rectifier tube, V301, produce the d-c voltage necessary for the plates and screens of the amplifying tubes. Voltage regulation as required for best operation of the oscillator and various other stages is accomplished by two voltage regulator tubes, V302 and V303. Bias voltage is also obtained from this power source. Filament power is derived from

the filament windings of T301. The input power is filtered in the low-pass filter section (fig. 4-2B) to minimize radio-frequency interference.

CIRCUIT ANALYSIS

PRESELECTOR SECTION

Antenna Input

The signal input connections from the antenna to the receiver (R-482A/URR-35) are made through a 50-ohm coaxial cable to the 50-ohm antenna jack, J404 (fig. 4-2B) on the bottom of the low-pass filter. The path of the signal is continued from the filter along another short length of coaxial cable (not shown) to a coaxial receptacle, P101, (fig. 4-5).

The inner conductor of P101 connects through C161 and L121 to ground. The signal developed across L121 is inductively coupled to L102 at the r-f amplifier input.

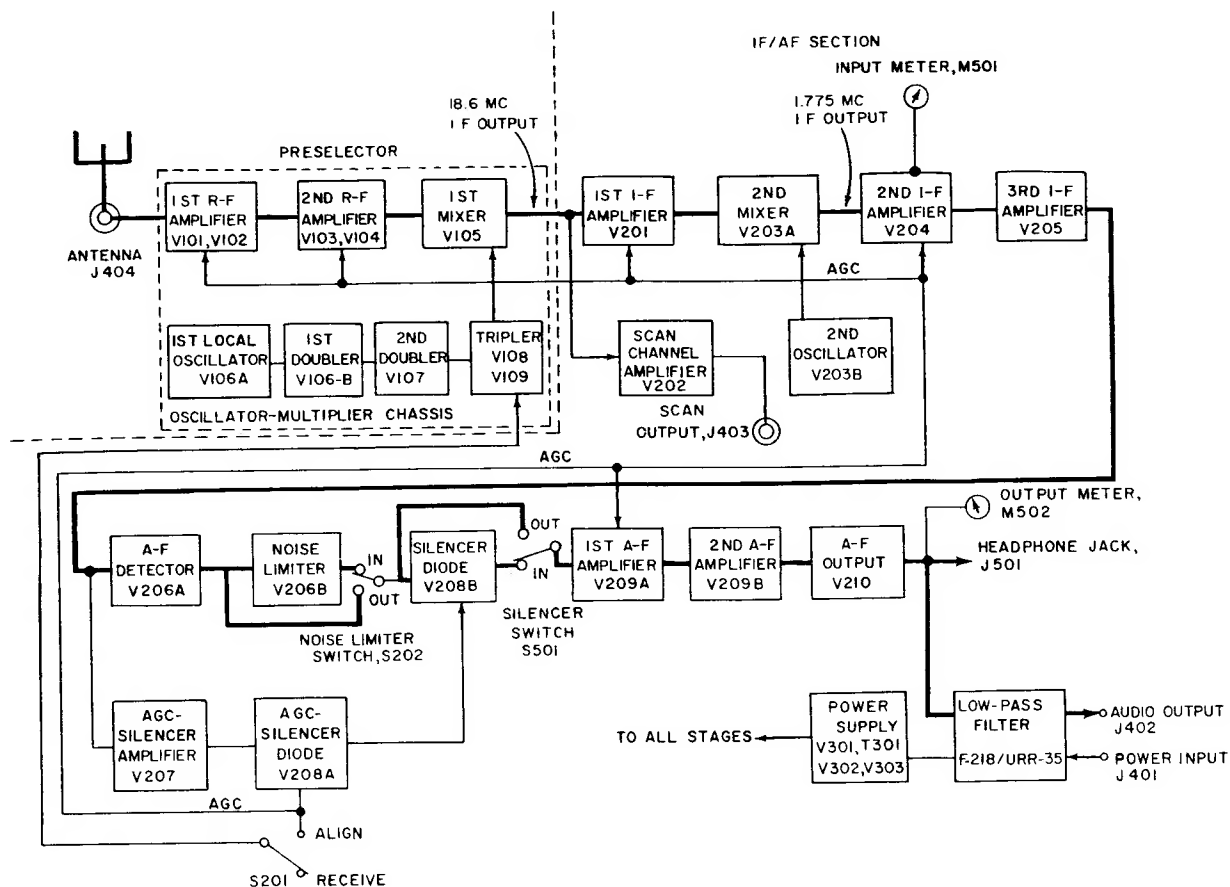


Figure 4-4.—Radio Receiver, R482/URR-35, block diagram. ^{32.61}

C101 tunes out the inductive reactance properties in the antenna input circuit. L101 is an assembly consisting of an outer conductor of bent seamless and silver-plated copper tubing which shields the inner conductor.

R-F Amplifiers

The grid and plate circuits of the two r-f amplifier stages, comprising V101 through V104, (fig. 4-5), and the grid circuit of the mixer stage, comprising V105A and V105B, are arranged in push-pull, and are tuned by a balanced-type five-gang air dielectric capacitor, C101. Each section of this capacitor (fig. 4-6) consists of a split-stator plate and a rotor plate which are mounted on a common metal shaft. The C101 rotor is grounded to the chassis frame by wiping contacts (not shown).

Concentric-type trimmer capacitors (C140 through C144) are used for aligning the high frequency end of the tuned circuits in the r-f

amplifier and mixer stages (fig. 4-5). Each of the trimmers (fig. 4-6) consists of a metal block (C) mounted on one stator section, and a partially threaded rod (R) which extends from a bracket (B) on the other stator section into the center bore of the block. An insulating tube (not shown) is contained in the bore of the block which serves as the dielectric. The block and rod constitute, respectively, the stator and rotor plates of the trimmer capacitor. The capacity of the trimmer is varied by turning the rod to adjust the amount of the projection into the block.

Alignment at the low frequency end of the tuning range is accomplished by padder inductances, L103, L104, L107, L108, and L111 (fig. 4-5). Each of the inductors (fig. 4-7) consists of two parallel round rods (L) and (L'), which are connected by a shorting bar (S). Positioning the shorting bar, by turning the adjustment screw, varies the inductance of the padder coil. An enlarged view of the screw and shorting contact is shown at the top of the illustration.

CIRCUITRY OF SHIPBOARD ELECTRONICS EQUIPMENT

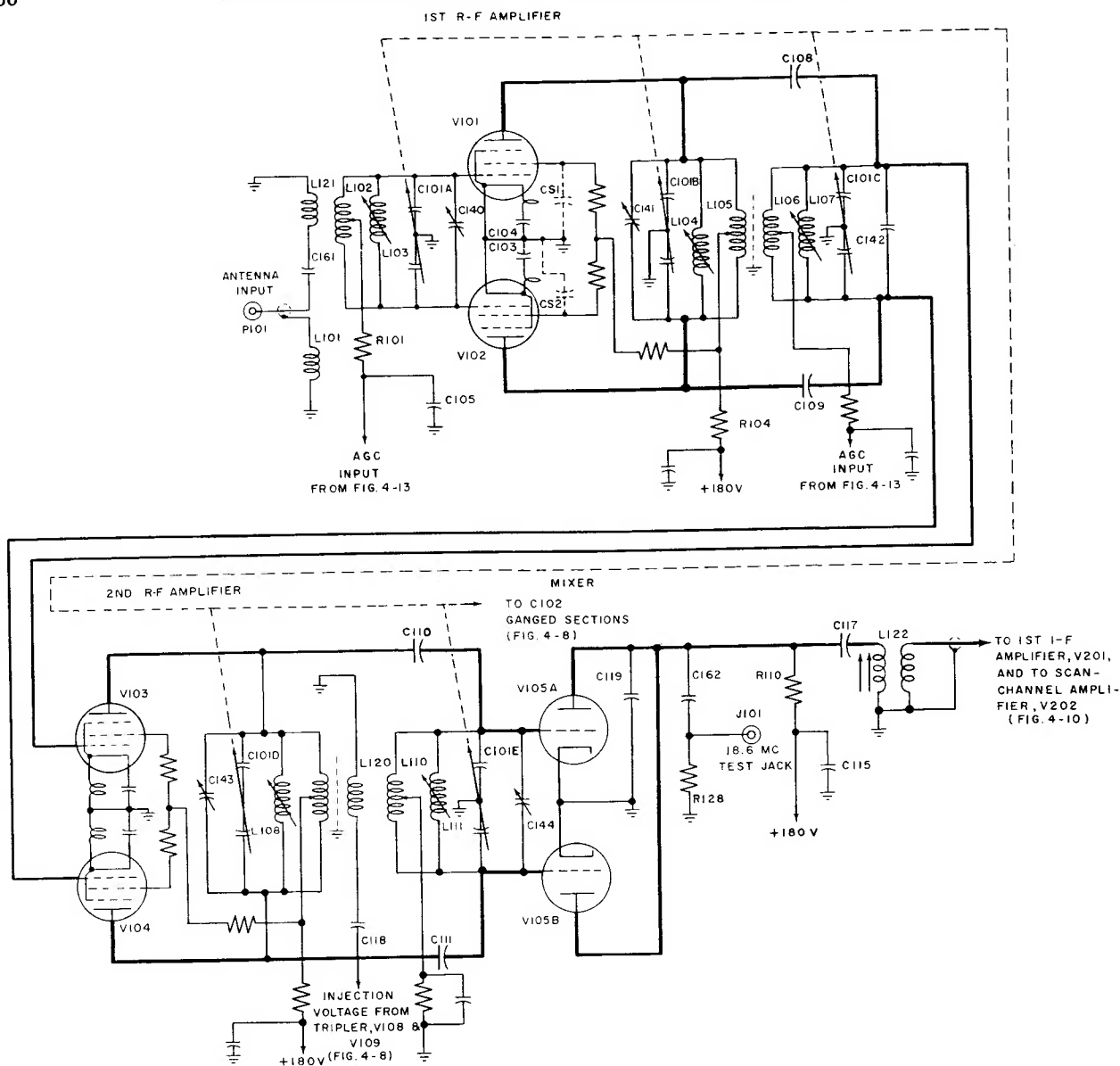


Figure 4-5.—R-f amplifier and mixer stages of preselector section. 32.62

The input circuit to the first r-f amplifier, V101 and V102 (fig. 4-5) consists of an inductance, L102, padder inductance, L103, section A of tuning capacitor, C101, and trimmer capacitor, C140. Critical coupling from L121 to L102 is employed in order to maintain uniform sensitivity over the entire frequency range. The push-pull arrangement of V101 and V102 approximately halves the tube capacitance, permitting a greater range of frequency coverage with higher circuit efficiency range. The push-pull arrangement of V101 and V102 approximately halves the interelectrode capacitance

that would be presented by single-ended operation. This decrease of effective tube capacitance increases the upper frequency of the stage.

Operating bias for the first r-f amplifier tubes (V101 and V102) is obtained from the AGC circuit through R101 and the center-tap of L102. This potential is established between the grid and cathode of V101 and V102. C105 is a feed-through capacitor which bypasses high frequency variations around the AGC line.

The V101 and V102 screen grids are bypassed to ground by stray or distributed capacitances, SC1 and CS2. This capacitance exists between

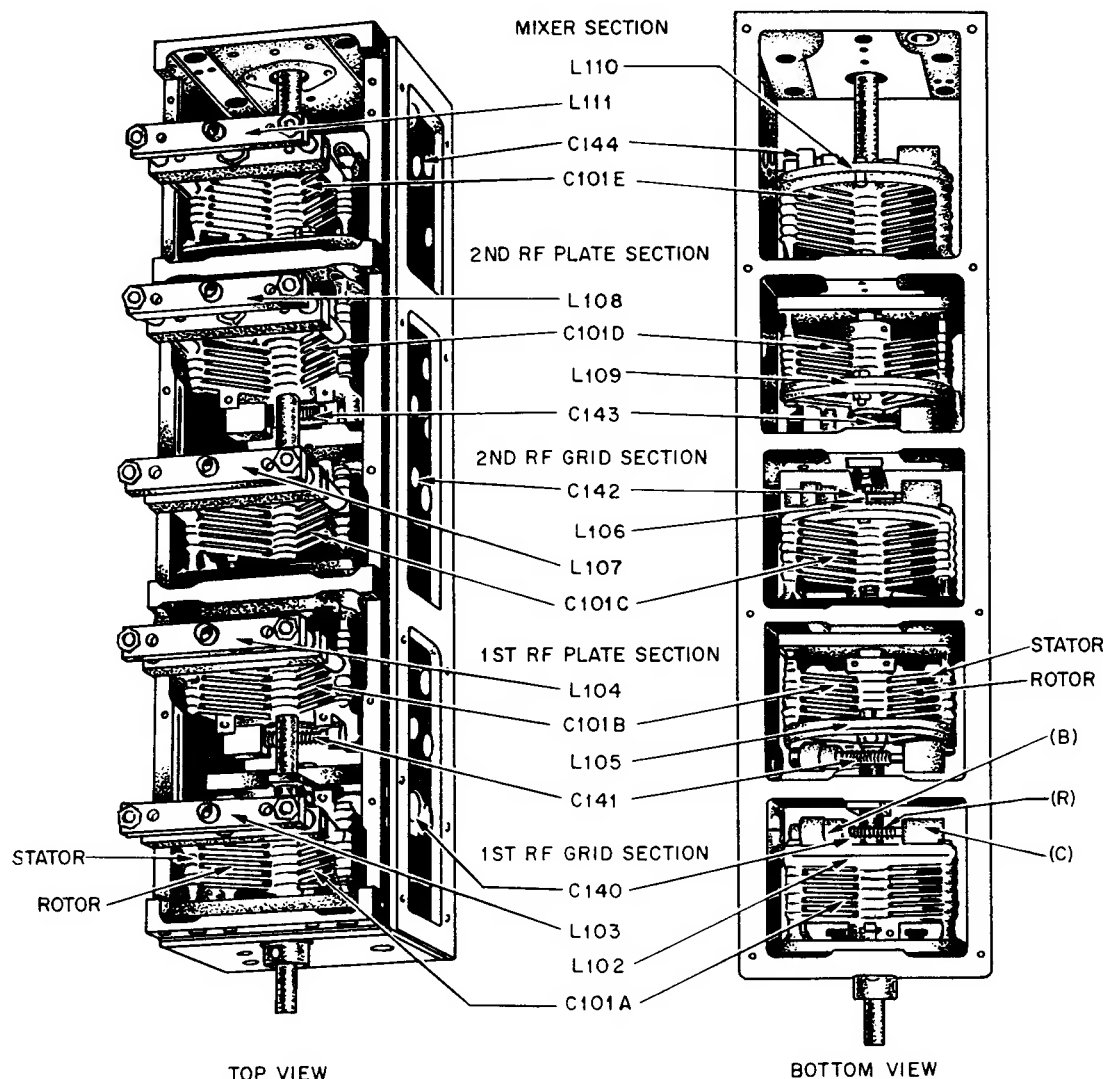


Figure 4-6.—R-f amplifier and mixer tuning assembly.

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the socket pins and/or socket wiring and the chassis. C103 and C104, in the cathode circuit, tune out the inductance of the cathode leads, and therefore tend to hold the V101 and V102 cathodes nearer to r-f ground potential.

The plate tuned circuit of V101 and V102 is similar in design to the grid circuit, and contains tank inductance, L105, tuning capacitor, C101B, padder inductance, L104, and trimmer capacitor, C141 (fig. 4-6). Plate voltage is applied through dropping resistor, R104, (fig. 4-5), and the center-tap of L105.

The amplified output of V101 is coupled by C108 to V103 in the upper section of the second r-f amplifier, which is also operated push-pull. V102 couples its output via C109 to the lower

tube (V104). No appreciable inductive coupling exists between the plate circuit of the first r-f amplifier and the grid circuit of the second r-f stage, because of the grounded metal shielding wall placed between L105 and L106. Coupling by the capacitors (C108 and C109) is more efficient at these frequencies, since for the high frequencies used, the impedance in the coupling path will be low. Otherwise, in order to maintain constant gain with inductive coupling over 225 to 400 mc, the coupling must decrease as the frequency increases. Eliminating inductive coupling eliminates the need for a variable coupling.

The second r-f amplifier, comprising V103 and V104, is identical in design to that of the

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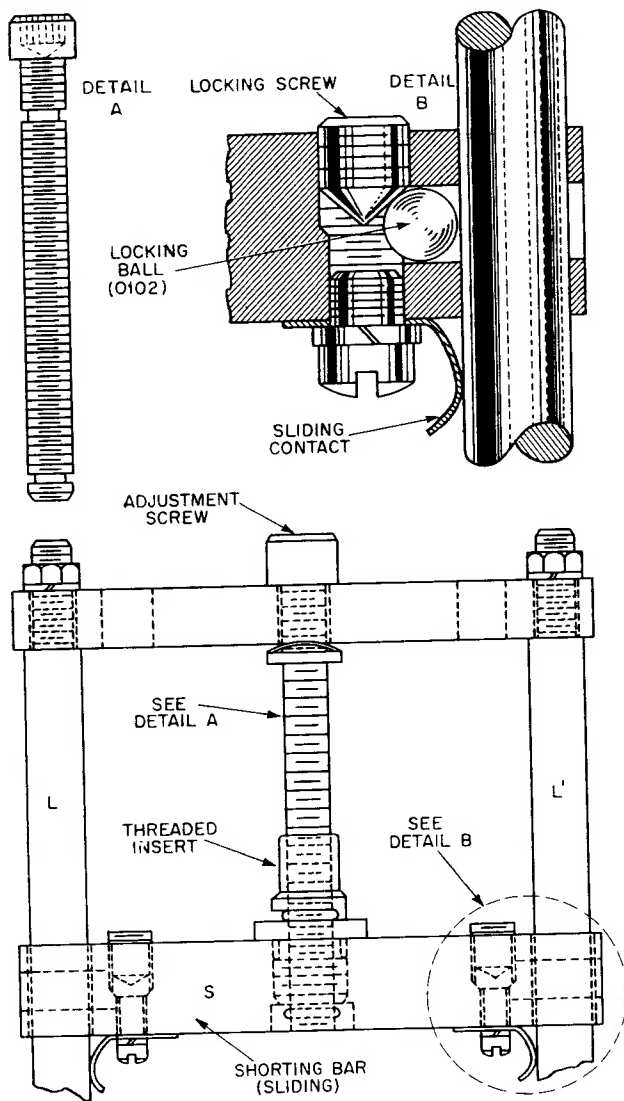


Figure 4-7.—Construction of the r-f amplifier and mixer padder inductances.

first r-f stage. The input (grid) tuning capacitor is C101C.

Local Oscillator and Multipliers

The oscillator-multiplier section of the pre-selector (fig. 4-4) generates a local injection signal which is 18.6 mc higher in frequency than the received signal. The basic oscillator frequency is generated in a cathode-coupled crystal-controlled circuit, comprising V106A and V106B (fig. 4-8). The oscillator circuit arrangement is that of a Butler oscillator.

You may recall that the master oscillator for the transmitter in the TED series (discussed in chapter 2) is also a Butler circuit. The circuit construction and the operation of the two oscillators are identical, except for the addition of the oscillator switch, S203, in the local oscillator stage, V106 (fig. 4-8).

The V106 oscillator functions as a crystal-controlled circuit when the OSC switch (S203) is in the CRYSTAL position, as shown. The crystal, Y201, operates in a series resonant mode to establish the frequency of the feedback voltage from the cathode of V106B to the cathode of V106A. C159, connected in series with the crystal, is used to resonate with the inductance of the crystal leads, so that zero phase shift exists between the two cathodes.

With S203 in the CRYSTAL position, the final local oscillator frequency to the mixer, V105 (fig. 4-5) will lie between 241.35 and 422.60 mc as determined by the crystal selected. Since the crystal frequency is multiplied 12 times (see fig. 4-4), any crystal having a fundamental frequency between 20.1125 and 35.2167 mc may be used.

For manual tuning, OSC switch, S203, (fig. 4-8) is in the MANUAL position (opposite to that shown) and crystal, Y201, is shorted out by the closed switch contacts. The V106 circuit will continue to operate, but as a free-running oscillator. The frequency of the oscillations will be determined by the setting of the oscillator section of the tuning capacitor, C102A. Since the feedback path between the cathodes of the two triode sections will no longer be frequency selective, the stability of the free-running oscillator circuit will not be as high as that for the crystal controlled circuit.

During manual operation, the range of the oscillator is from 20.2063 to 35.05 megacycles. The frequency at the output of the multiplier stages (fig. 4-4) will range from 242.4756 to 420.6 megacycles. Thus, the radio receiver will be operative over a range of input frequencies from 223.875 to 402.0 megacycles.

For manual tuning, the receiver may be operated with or without a crystal in the crystal socket. However, since the original factory adjustments and alignment of the receiver were made with a crystal in the socket, it follows that the dial calibration will be more accurate, and the receiver gain greater, if the receiver is operated in the same manner during MANUAL operation in the field.

In the neighborhood of 400 mc, the resonant frequency of the oscillator increases approximately 0.1 percent when the crystal is removed

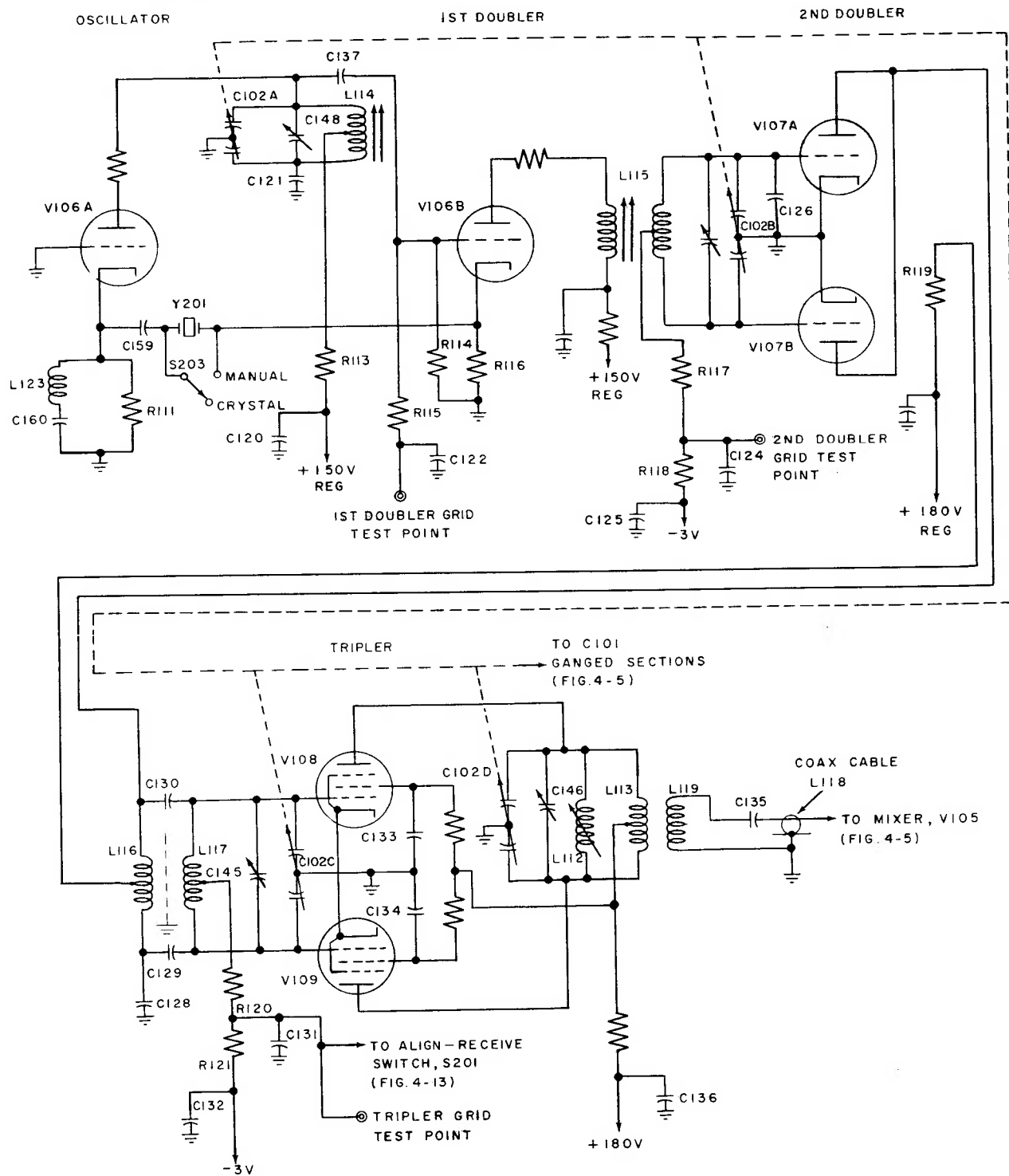


Figure 4-8.—Oscillator-multiplier section of preselector. ^{32.65}

from the socket. At frequencies near 225 mc, an oscillator frequency increase of about 0.04 percent occurs when the crystal is removed. This effect is attributable to the fact that there is some capacity between the crystal, crystal-holder, and ground which influences the oscillator frequency even though the crystal is shorted by S203. The crystal-to-ground capacity effectively exists from the cathode of the oscillator and doubler stages to ground. Removing the crystal from its socket lowers the capacitance and thereby causes an increase in the frequency of the oscillations.

The oscillator (V106A) plate tank circuit comprises tuning capacitor, C102A, trimmer capacitor, C148, and tank inductance, L114. C121 balances the tank circuit to ground by providing the same capacitance between the lower end of the tank and ground as is provided by V106A between the upper end of the tank and ground.

Plate voltage for the oscillator tube, V106A, is fed through dropping resistor, R113, and the center-tap of tank inductance, L114, from the +150 volt regulated supply. C120 bypasses high frequency variations around the B supply.

L123, C160 and the heater-to-cathode capacitance of V106A form a broadly tuned series resonant circuit near the mean frequency of the oscillator. The reactance of L123 tunes out the heater-to-cathode capacitive reactance so that the cathode current is in phase with the cathode voltage. With the reactive properties of the heater-to-cathode capacitance tuned out, the phase shift of the signal applied from the cathode of the first doubler, V106B, to the oscillator (V106A) cathode is as small as possible. This prevents a shift in the phase of the feedback voltage. C160 is connected in series with L123 across R111 to prevent shorting the bias voltage developed across R111 by the low d-c resistance of the coil.

The plate output of the oscillator stage, V106A, is coupled through C137 to the grid of the first doubler, V106B. The grid input signal through C137 drives the V106B grid positive with respect to its cathode during the most positive portion of each input cycle. Thus, the V106B grid draws a current during this period, and C137 charges negative toward the grid.

When the grid input signal drops below a value which does not permit the V106B grid to continue to draw a current, C137 partially discharges through R114 to establish a grid leak bias between the grid and cathode of V106B.

Plate voltage for V106B is applied through the untuned primary of L115, from the +150 volt

regulated B supply. L115 is space wound with two #20 wires side by side to form a single layer of two coils on a common powdered iron core. This type of winding is called a bifilar winding which means two filaments side by side (like a double-threaded screw).

The grid coil contains 6 turns, which are tapped slightly off-center at $2 \frac{7}{8}$ turns from one end. The plate coil has $5 \frac{3}{8}$ turns. Both coils are wound on a single powdered-iron core, whose projection into the coils is adjustable.

The first doubler (V106B) cathode resistor is unbypassed so that the r-f voltage across R116 can be fed without phase shift across R111 in the V106A oscillator cathode. The values of R111 and R116 are chosen so that the positive feedback is limited to the value necessary to sustain oscillations at the series resonant frequency of the crystal; the feedback is large enough to prevent oscillations at other frequencies which might otherwise occur due to the capacitance across the crystal holder.

The secondary of L115 in the first doubler (V106B) plate is designed for operation at the second harmonic of the crystal oscillator frequency. Because of this, the plate circuit impedance at the oscillator frequency is very low, resulting effectively in grounded-plate operation of the first doubler at this frequency. The impedance at the second harmonic of the crystal oscillator frequency is high. Thus, the doubler output is developed across the plate components, and the transformer coupled to the second doubler, V107A.

A test point is provided at the grid of the first doubler (V106B) to facilitate measurement of the d-c bias on the tube. The measured voltage is indicative of the amount of drive from the oscillator. R115 and C122 decouple the grid circuit from the point of measurement to prevent stray r-f signals from being introduced into the first doubler stage via the test point jack.

The second doubler stage employs V107A and V107B in a push-push circuit arrangement (grids in pushpull, plates in parallel). The second doubler grid tuned circuit consists of the center-tapped secondary of L115, section B of ganged capacitor, C102, and trimmer capacitor, C147.

As mentioned earlier, the tap on the L115 secondary is not at the exact center, and the distributed capacitance to ground from either end of the coil is not the same. Thus, C126 is connected from the grid of V107A to ground to compensate for the capacitance unbalance on the side containing the smaller capacitance.

The V107A and V107B grids are returned through the L115 secondary tap and through

R117 and R118 to a -3 volt potential obtained from the power supply (not shown). This potential is applied between the cathodes and the respective grids of V107 as a bias voltage to prevent excessive rise in plate current if the signal (driving) voltage is removed. C124 prevents the introduction of undesired radio-frequency signals at the second doubler grid test point. G125 bypasses the -3 volt supply.

The plates of V107 are tied in parallel, and connected through the plate load (the upper section of L116) and a dropping resistor, R119, to the +180 volt B supply. L116 is center-tapped and functions as an autotransformer. The autotransformer action supplies balanced signal voltages, 180° out-of-phase, to the separate grids of the push-pull operated tripler stage comprising V108 and V109. C128 is connected from the bottom of L116 to ground in order to make the capacitance in this path balance with the output capacitance of the second doubler tubes (V107A and V107B) from the top of L116 to ground.

The output of the second doubler (V107) is coupled by C129 and C130 to the tripler stage. No appreciable inductive coupling exists between L116 and L117, since the two coils are isolated by the grounded preselector casting.

The push-pull circuit arrangement of the multiplier stage, (V108 and V109) and the center-tapping of the coupling coil, L113 suppress the amplification of even order harmonics in this stage. Thus, the push-pull arrangement minimizes the amplification of undesired spurious signals which might otherwise be amplified and radiated by the receiver antenna. The parallel resonant grid circuit of the tripler stage (fig. 4-8) consists of L117, C102C, and C145. This circuit is tuned to the fourth harmonic of the oscillator frequency and comprises the load on the second doubler V107.

The -3 volt protective bias applied to the tripler grids is bypassed to ground by C132. R120 and R121 develop the grid leak bias. A tap at the junction of these resistors provides a metering point for checking the grid driving signal. The voltage at this point is also used during receiver alignment as will be seen later.

The V108 and V109 tripler plate circuits are tuned to a frequency which is three times their grid input frequency. Thus, the multiplier chain produces a total multiplication of 12, and a resulting output frequency which is 18.6 mc higher than the receiver input frequency. The tripler plate circuit is a parallel resonant combination of L112, L113, C102D, and C146. C133, C134,

and C136 are bypass capacitors for radio frequencies.

The output of the tripler stage is coupled through L119, and thence through C135 to the output of the oscillator-multiplier section of the preselector. C118 and L120 (on the r-f converter chassis of figure 4-5) couple the tripler output to the grids of the mixer stage (V105A and V105B) via L120 and L110.

Coupling between the oscillator-multiplier and r-f amplifier sections of the preselector is accomplished by inductance, L118. L118 (fig. 4-8) is a 3 3/16 inch length of coax cable which acts as a coil to provide inductive coupling between the two units. The construction of the cable is as illustrated in figure 4-9. It consists of a copper inner conductor (0.032 inch in diameter), and a silver plated copper tube outer conductor with a diameter of 0.140 inch. The two conductors of the coax are separated by a polyethylene dielectric. The L118 coax coupling arrangement maintains a more uniform mixer-injection signal voltage over the operating frequency range.

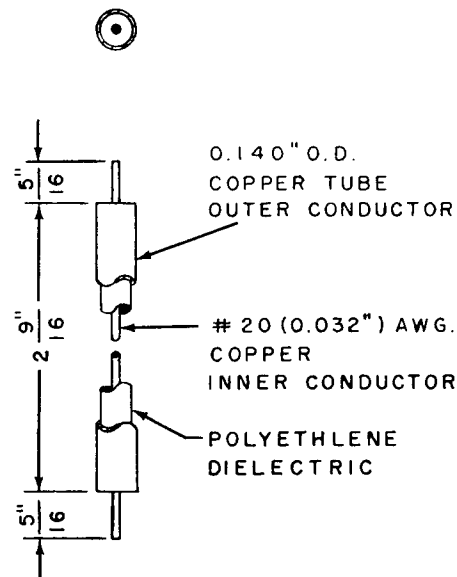


Figure 4-9.—Coupling inductance, L118.

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The values of C118 (fig. 4-5) and C135 (fig. 4-8) together with the shunt capacity of the coaxial connecting line and the coupling coils are so chosen that the coupling loop makes up a series resonant circuit at a frequency below the low end of band, and a parallel resonant circuit at a frequency above the high end of the band.

The two resonant frequencies correspond to approximately 190 and 470 mc respectively.

At the low frequency end of the band, the impedance of the coupling circuit is decreased, and the voltage induced into the mixer, V105A and V105B, input tank (fig. 4-5) is increased. At the high end of the band, the coupling circuit approaches parallel resonance with an accompanying increase in impedance. Thus, the signal coupled by L110 to the mixer grids (V105A and V105B) is reduced.

If the coupling circuit were not designed so that the impedance of the circuit changed in this manner, the L110 induced voltage would tend to drop off at the low end and increase at the high end of the band (inductive coupling gain varies with frequency).

The V105A and V105B mixer grids (fig. 4-5) are connected in push-pull from the input tuned circuit which consists of C101D, C144, L110, and L111. The V103 and V104 (second r-f amplifier) output is coupled by C110 and C111 to the grids of V105A and V105B, respectively. The oscillator output (via the tripler stage of fig. 4-8 as discussed) is coupled by L110 to the mixer grids, and is 18.6 mc megacycles higher in frequency than the incoming r-f signal.

The plate of the mixer tubes (V105A and V105B) are connected in parallel and tied through R110 to the +180 volt B supply. C117, C119, and the L122 primary form a resonant tank at the output frequency of the mixer, (18.6 mc). The plates of V105 are connected to the junction of the two tank capacitors (C117 and C119) in order to provide impedance matching between the tube and tuned circuit. C117 also acts to block the d-c plate voltage from the output coil, but allows the mixer signal output to be developed across L122. The push-push arrangement of the mixer permits a higher gain to be obtained from the mixer, since the push-push transconductance is approximately twice that of a single converter tube.

Decoupling is accomplished by C115. J101 is a test point which permits test signals to be inserted (via C162) into the mixer output transformer. R128 serves to terminate the test signal source, C117 couples the signal to the mixer output transformer (L122) primary.

IF/AF SECTION

First I-F Amplifier

The output of the mixer stage (V105A and V105B) is linked coupled from L122 (fig. 4-5) to the primary of T201 (fig. 4-10) and thence to the

grid circuit of the first i-f amplifier stage, V201. This method of coupling is made necessary by the physical layout of the equipment.

The mixer plate transformer, L122 (fig. 4-5) and the primary of the i-f input transformer, T201, (fig. 4-10) are located on different sections of the preselector chassis. A length of RG58/U coaxial cable joins the secondary winding of L122 and the primary winding of T201. Since the impedance of the RG58/U cable is 50 ohms, a low-impedance inductive coupling exists between the mixer and first r-f stages.

The secondary of the i-f input transformer, T201, is tuned to resonance at 18.6 megacycles. The transformer output is applied directly to the first i-f amplifier (V201) grid, and to a scan-channel amplifier, V202 via C203. The operation of the scan-channel amplifier will be treated in detail later.

V201 functions as a conventional i-f amplifier, except that the i-f gain control, R233, is connected in the plate and screen circuits as opposed to its more common location in the cathode. The effect of varying R233 is to change the plate and screen voltages, and thus change the gain of the first i-f stage.

The V201 output signal is applied to the primary of the first i-f output transformer, T202. This transformer is shielded, and double-tuned to resonate at the 18.6 mc intermediate frequency by the adjustable iron slugs. The pass-band characteristics of T202 are as illustrated in figure 4-11.

Second Oscillator and Second Mixer Stages

The second oscillator, V203B, (fig. 4-10) is crystal-controlled to produce the second heterodyning frequency required for the operation of the receiver. The second mixer stage, V203A, receives the 18.6 mc i-f signal from V210 at its control grid (through suppressor resistor, R266), while a signal 1.775 mc below the V201 output from the second oscillator, V203B, is applied to the second mixer (V203A) cathode.

The V203B oscillator circuit is connected as a conventional crystal-controlled oscillator, with the crystal, Y202, and the crystal holder applying its parallel resonant frequency voltage between the control grid and cathode of V203B. Grid leak bias for the oscillator is established by the action of the capacitance of the crystal holder and the discharge of this capacity through R209. Plate voltage is obtained for V203B from a +105 volt supply through T203. L206 and the resistance (R) of T203 operate in conjunction

the V203A plate. The T204 primary tuned tank, which acts as the plate load of V203A, is tuned to the difference frequency (1.775 mc). T204 is tuned with two ceramic capacitors, a resistor, and adjustable iron core. The plate tank is sharply tuned to 1.775 megacycles.

The T204 secondary is also tuned to 1.775 megacycles. The secondary output is coupled by C210 to the primary (input) tank of the second i-f amplifier, V204.

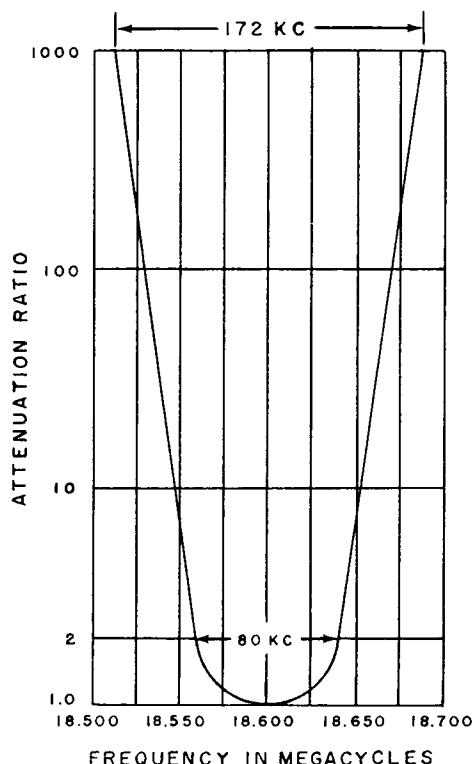


Figure 4-11.—I-f selectivity characteristics. 32.68

Test point, J202, is provided for checking the operation of the crystal oscillator, V203B. C244 and R210 form a low-pass filter network which isolates the grid of the oscillator from the meter being used to measure the grid bias. When the bias measurement is being made, the current necessary to cause the meter deflection will be drawn primarily from C244. This prevents any appreciable change in the current being drawn from the capacity of the crystal holder, and does not therefore greatly alter the oscillator bias.

J201 permits external test signals to be applied through C207 to the i-f circuits. R207 is provided to terminate the test signal source.

Second and Third I-F Amplifier Stages

The second and third i-f amplifier stages, V204 and V205, respectively (fig. 4-10), are connected as conventional i-f stages. The components and circuitry of the two stages are almost identical. The essential difference between the two i-f amplifier stages is that the gain of the second i-f amplifier stage, V204, is

controlled by the AGC voltage, while the third i-f amplifier stage, V205, is self-biased.

The interstage coupling networks, consisting of T204 and T205 between the second mixer and second i-f amplifier, and T206 and T207 between the second and third i-f amplifiers, are each quadruple-tuned at 1.775 megacycles. The circuits help produce an i-f passband which is relatively flat at the top, and yet retains the desired selectivity. The slope of the passband curve is similar to that shown in figure 4-11.

T208 (fig. 4-10) is a conventional double-tuned i-f transformer. The third i-f amplifier, V205, output is coupled by T208 to the detector, V206A (fig. 4-13) and to the AGC silencer amplifier, V207. The operation of these circuits is treated in detail later.

Scan-Channel Amplifier

A panoramic adapter may be used with the receiver when it is desired to view the received signals. The scan-channel amplifier, V202 (fig. 4-12) is provided to amplify the signal which is to be fed to the adapter. The stage functions as a conventional amplifier which receives the 18.6 mc i-f output of V105 (fig. 4-5). The input signals to V202 (fig. 4-12) are coupled by C203 and developed at the V202 grid across R203. Plate output variations are coupled by C204 to the scan output terminal, P201. From P201, the output is fed to the adapter.

When the scan-channel output is not being used, the scan-channel circuit is terminated at P201 by a 47-ohm resistor located in the terminating cap, E401 (fig. 4-2B).

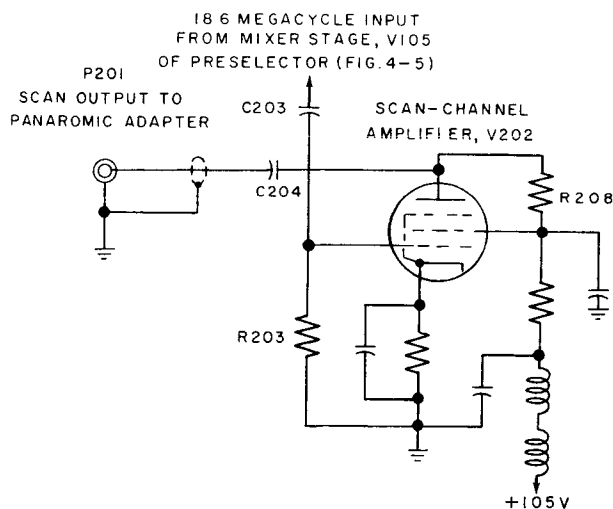


Figure 4-12.—Scan-channel amplifier. 32.69

Detector and Noise Limiter

V206A (fig. 4-13) functions as a conventional diode detector stage. The modulated i-f input is coupled by T208 to the detector diode (V206A) plate. The load components for the diode consists of R226, R227, and R229. The voltage developed across these resistors is filtered by C220, C221, and C222, so that the detector output is essentially an audio frequency voltage.

The path of the detector output signal from the R226-R227 junction to the first audio voltage amplifier, V209A (fig. 4-14) is determined by the setting of the noise limiter switch, S202 (fig. 4-13). If this switch is in the OUT position (opposite to the position shown) the detector output (from the R226-R227 junction) will be fed through the "out" contacts of S202, through C227, R235, and V208B, to the first audio amplifier.

V206B functions as a series diode noise limiter. When S202 is moved to the IN position (position shown) V206B is placed in series with the audio output circuit and the silencer diode, V208B. The conducting and nonconducting condition of V206B will therefore determine the signal-pass and signal-stop condition of the silencer (V208B) output, and thus indirectly control the input to the audio voltage amplifier (V209A of fig. 4-14).

V206 is biased in the conducting direction by a +5 volt connection to the plate from the junction of a voltage divider made up of R232 and R227 connected from the +105 volt regulated B supply to ground. The operating point of V206B is selected to permit the conduction (forward) resistance of V206B to introduce an insertion loss of less than 3 db in the signal path.

The filter R228 and C223, when subjected to noise peaks, causes the V206B plate to go negative with respect to the cathode and thus cut off the diode conduction. The V206B plate-to-cathode voltage is the algebraic sum of the voltages across R231, R228, and R226. R231 is an isolating resistor. Normally the drop across R228 is less than that across R226 because C223 charges up to the average d-c voltage between the lower end of the T208 secondary and ground. C223 cannot follow noise peaks so they appear across R228. When the voltage across R228 exceeds the voltage across R226 the V206B plate becomes negative with respect to the cathode and the series diode limiter cuts off. This action effectively opens the audio output circuit so the noise peaks do not appear in the output.

AGC-Silencer Amplifier

The AGC-silencer amplifier, V207 (fig. 4-13), is a conventional amplifier circuit used to amplify the output from the i-f amplifiers to a level which is suitable for use in the AGC and silencer circuits. A -9 volt fixed bias potential from the power supply is applied to the V207 grid through R230.

The V207 plate load consists of a parallel resonant tank, T210, which is tuned to the intermediate frequency (1.775 mc). The amplified output of V207 is fed through C226 to the AGC-silencer diode, V208A.

AGC-Silencer Diode

The AGC-silencer diode, V208A (fig. 4-13), functions to produce the negative voltage for the AGC and silencer circuits. The V208A output is also used to assist in aligning the receiver when the align-receive switch, S201, is placed in the ALIGN position.

The AGC-silencer diode functions as follows: A -3 volt bias source is applied at the junction of R241 and R244, so that the potential at the R241-R242 junction (which is applied to the V208A plate) is approximately -1.8 volts. This potential acts as a delay bias for V208A to prevent the V208A conduction and the development of the negative AGC voltage during the reception of weak signals.

When the peak value of the 1.775 mc i-f signal coupled through C226 to V208A exceeds the delay bias in the positive direction, V208A conducts. When V208A is conducting, the low conducting resistance of the tube essentially short-circuits R242, R243, and R240, which are connected in parallel across V208A. During this conduction period, C226 charges to approximately the peak value of the input pulse.

Negative input pulses will not permit V208A to conduct. Rather, this input reinforces the charge developed across C226, during the positive alternation, causing a large current to be conducted through R240, R243, and R242, during the period of the negative input. The potential developed across the divider is negative to ground. The voltage which is obtained at the junction of R240 and R243 is the negative AGC voltage.

C231, R245, and C228B filter the AGC voltage so that it is essentially d-c. C231 (the smaller of the two filter capacitors) bypasses radio frequencies around the AGC line. C228B

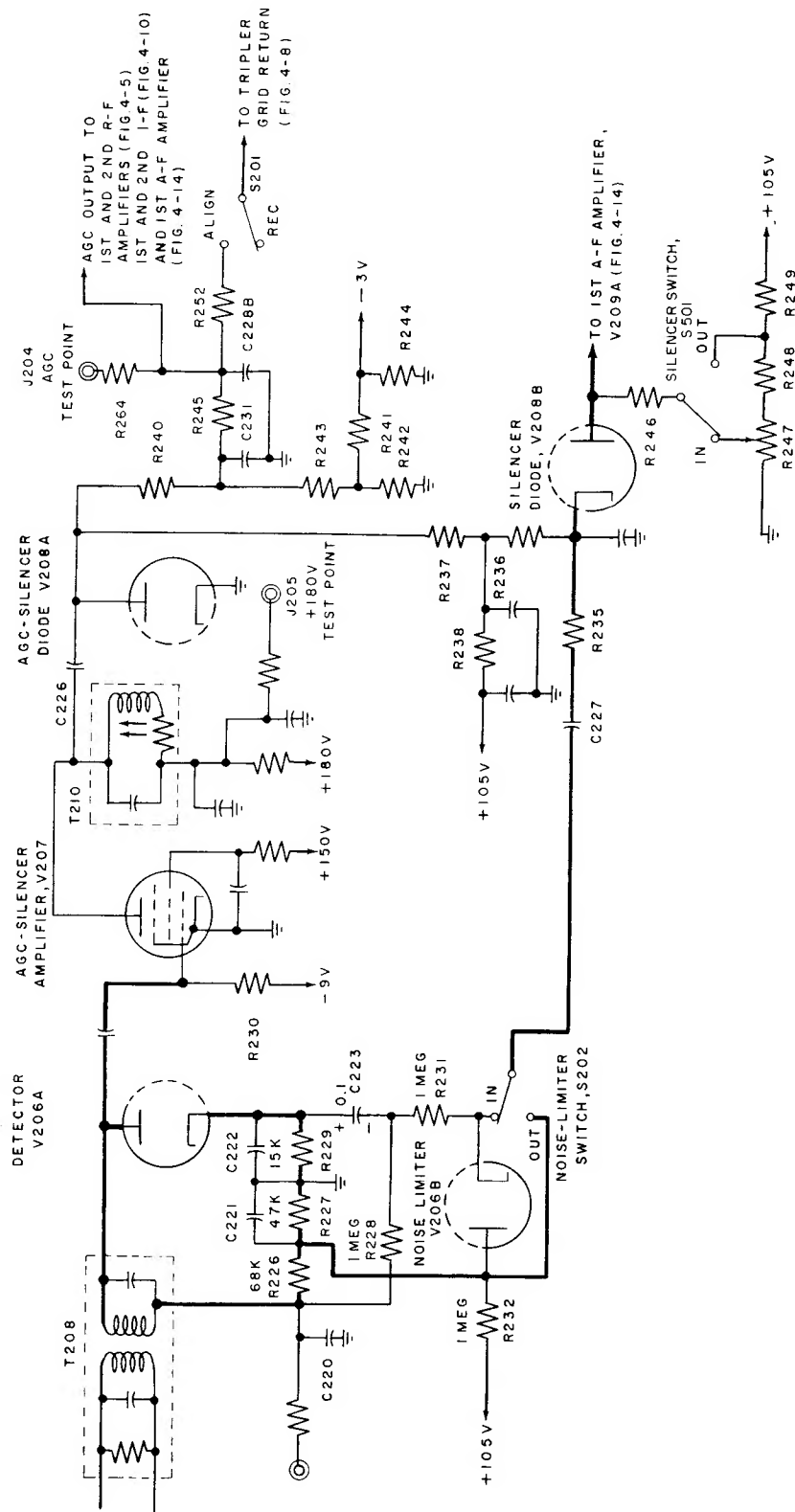


Figure 4-13.—Detector, AGC, silencer, and noise limiter circuits. ^{32.70}

and R245 are primarily responsible for the removal of the audio frequency of the voltage.

The AGC potential is applied from the R245-C228B junction to the first and second r-f amplifiers, comprising V101 and V102, and V103 and V104, respectively (fig. 4-5). This potential is also applied to the first and second i-f amplifiers, V201 and V204, respectively (fig. 4-10). Finally, the AGC voltage potential is applied to the first a-f amplifier, V209A (fig. 4-14). R-C decoupling networks are employed in the grid circuits of each of the AGC-controlled r-f and i-f amplifiers.

A minimum bias of -1.8 volts (fig. 4-13) is present at the control grid of each of the AGC-controlled stages, regardless of whether or not an AGC voltage is developed from the received

signal. This potential is derived from the connection of the AGC line through R245 and R243 to the -1.8 volt tap on the voltage divider comprising R241 and R242. This minimum value of bias voltage keeps the r-f, i-f, and a-f stages operating at the proper point on their eg-ip curves during the reception of weak signals. The magnitude of the AGC voltage may be checked at J204, which is connected to the AGC line through isolating resistor, R264.

Silencer

The silencer, or squelch circuit is used to prevent noise from reaching the audio section of the receiver in the absence of an incoming signal of some predetermined minimum level.

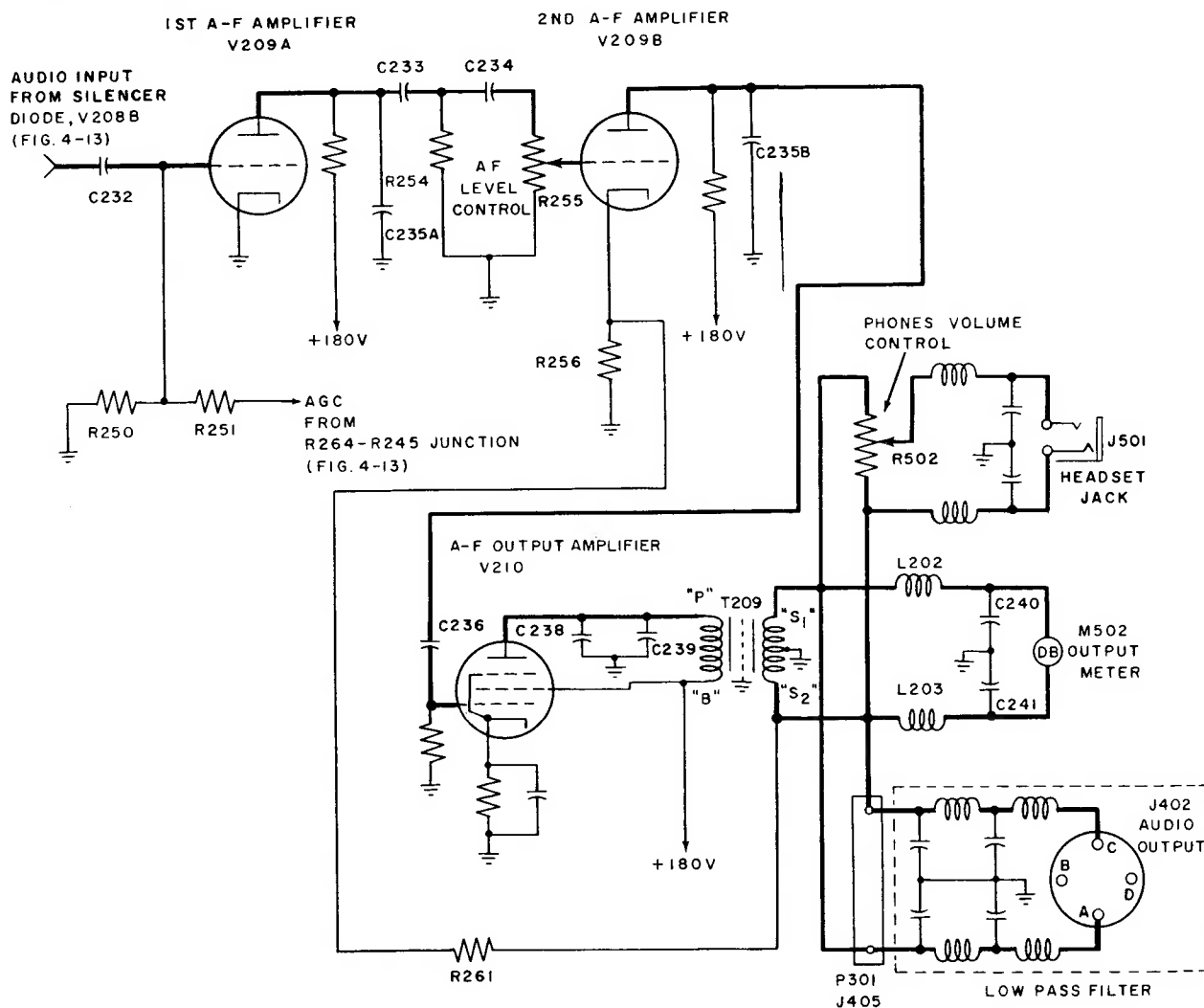


Figure 4-14.—Audio amplifier stages.

The silencer diode, V208B (fig. 4-13) is series connected between the noise limiter switch, S202, and the first audio amplifier, V209A (fig. 4-14). When V208B (fig. 4-13) is conducting, the audio signal is permitted to pass to the audio stages. When V208B is cut off, the squelching action of the circuit is effective to prevent the noise and audio signals from reaching the audio section of the receiver.

The squelch circuit may be made operative or inoperative by means of the silencer switch, S501. A silencing potentiometer, R247, is used to adjust the silencing threshold.

The action of the silencer circuit is as follows: the plate of the silencer diode, V208B, is connected through R246 to a point on a voltage divider comprising R247, R248, and R249. The divider is connected between the +105 volt supply and ground. If the silencer switch, S501, is in the IN position (as shown) the positive potential will be obtained from the arm of the silencer control, R247. This control establishes the sensitivity of the silencer circuit as will be seen later. If S501 is in the OUT position (opposite to that shown) the positive plate of V208B is obtained from the R248-R249 junction.

Although the plate potential of V208B is always either positive or at ground potential (depending on the position of S501 and the setting of the R247 arm) V208B may or may not be conducting as a result of a positive V208B cathode potential. In normal operation, with no receiver signal, a quiescent current is conducted from the -3 volt supply through R241, R243, R240, R237 and R238 to the +105 volt supply. The V208A plate potential is maintained negative to ground by a potential obtained from the R240-R237 junction. Also from this voltage divider, the cathode of the silencer diode, V208B, is held at about +30 volts derived from the R237-R238 junction and applied through R236 to the V208B cathode.

When the silencer switch, S501, is in the OUT position (opposite to that shown) the diode plate potential is approximately +58 volts. As stated earlier, this potential is obtained from the R248-R249 junction and applied to the V208B plate through R246. Because the plate of the silencer diode, V208B, is much more positive than the cathode (with S501 in the OUT position) V208B constantly conducts. Thus, any signal or noise applied from S202 to the V208B cathode will vary the V208B cathode potential and will therefore be passed through the diode to the first audio amplifier, V209A (fig. 4-14). The silencer circuit is inoperative since in the OUT position V208B (fig. 4-13) conducts when a

signal is present or in the absence of input signals.

The silencer circuit is made operative by placing the silencer switch, S501 in the IN position. In this position, the plate of V208B is connected through R246 to the arm of the silencer potentiometer, R247. R247 permits adjustment of the plate voltage from zero to +36 volts. Because of the +30 volt cathode potential, as discussed, the silencer diode may or may not conduct, depending on the setting of the R247 arm, and the resulting V208B plate potential. With no received signal, the arm of R247 is set just beyond the point (in the less positive direction) which cuts off the V208B diode, thereby preventing noise signals from passing through to the first audio amplifier, V209A (fig. 4-14).

When a signal which exceeds the noise level received from the AGC-silencer amplifier, V207, the discharge of C226 during negative portions of the input cycle will cause an increase in the negative potential developed across R240, R243, and the series-parallel combination of R242, R241, and R244. The electron flow is now downward through this divider. The increase in signal amplitude produces a negative voltage which is coupled through R237 to the R237-R238 junction. This negative-going potential is applied, in turn, through R236 to the V208B cathode to reduce the positive bias at the cathode and permit V208B to conduct. Thus, the audio signal which is fed to the V208B cathode from S202 will be passed through the silencer diode to the first audio amplifier, V209A (fig. 4-14).

Audio Amplifier Stages

The audio stages of the AN/URR-35A receiver (fig. 4-14) are conventional in most respects. The signal input from the silencer diode (V208B of fig. 4-13) is applied through C232 (fig. 4-14) to the control grid of the first audio amplifier, V209A. Bias voltage for V209A is obtained from a voltage divider comprising R250 and R251, which is connected from the AGC output to ground. C235A is connected from the plate to ground of V209A to bypass to ground (and therefore attenuate) the unwanted higher frequencies, so that only the voice frequencies necessary for efficient communication audibility are amplified.

The V209A output is applied to a two-section high-pass filter which helps establish the lower limit (350 cps) of the 350 to 3,500 cps audio passband. The filter is composed of G233, R254, C234, and R255.

Potentiometer, R255, is the AF level control. The voltage at the R255 arm is applied to the control grid of the second a-f amplifier, V209B.

Degenerative feedback is provided in V209B by the unbypassed cathode resistor, R256, and by a feedback potential which is fed from the secondary of the output transformer, T209, to the V209B cathode. To analyze this feedback circuit, let us first assume an instantaneous grid signal potential to be applied to the V209B grid. You will recall that the feedback potential must oppose the grid instantaneous signal in order to be degenerative to any amplifier.

Assume that the V209B grid signal swing is positive-going. The V209B plate current will be increasing, while the plate voltage will be decreasing. Thus, the signal applied to the grid of V210 (the a-f output amplifier) will be negative-going. The corresponding plate voltage rise and plate current decrease of V210 causes the top section "P" of the T209 primary to become more positive, while the bottom section "B" of the T209 primary will become less positive.

Because of the 180° phase shift from the T209 primary to the secondary, the bottom section "S2" will become more positive. The more positive voltage at "S2" is fed back through R261 to the V209B cathode so that it tends to cut down on the amount of the tube current increase as a result of the positive-going grid input signal. Thus, the feedback potential degenerates the normal actions of the amplifier.

The amplified output of the second a-f amplifier, V209B is coupled by C236 to the a-f output

amplifier, V210. V210 delivers approximately 1.1 watts to the audio output transformer, T209, with a nominal distortion of about 5 percent. C235B, C238, and C239 bypass high frequencies from the plates of the second audio and output amplifiers, respectively, and establish the high frequency limit of the audio circuit at 3,500 cps.

Audio signals from the a-f output stage, V210 are coupled by the electrostatically-shielded output transformer, T209 to the output circuits. The impedance step-down of T209 is 10.00 ohms to 60 ohms. The secondary provides balanced outputs.

Signals from the secondary of T209 are fed via an r-f filter composed of L202, L203, C240, and C241, to the output meter, M502. The meter is located on the receiver front panel (fig. 4-1).

The T209 secondary output (fig. 4-14) is also fed, via the phones volume control, R502, through a filter network to the headphones jack, J501. When phones are used at J501, the phones volume control, R502, provides an audio level adjustment separate from the main a-f level control, R255.

A third circuit applies the audio output through connectors P301 and J405 for external use. This output is filtered and applied to the audio output receptacle, J402. The receptacle is located at the rear of the receiver cabinet.

The filter circuits are made up of "L" sections which are connected to produce equal and opposite voltages to ground at stray r-f frequencies, to balance-out these frequencies. Thus, each of the filter networks shields its respective output from the influence of external r-f fields.